COURSE OUTLINE

School of Photovoltaic and Renewable Energy Engineering

SOLA 5052
Biomass & Bioenergy

Term 3 (T3), 2019

Lecturer:
Prof. Evatt Hawkes
Tyree Energy Technologies Building (H6)
Email: evatt.hawkes@unsw.edu.au

Course Coordinator:
Dr. Rob Patterson
robert.j.patterson@unsw.edu.au

Contents

1. Executive Summary

What is the course:

- This is an advanced level engineering course about the use of biomass for energy.

Who is teaching it:

- Course Coordinator: Dr. Robert Patterson (robert.j.patterson@unsw.edu.au)
- Lecturer: Prof. Evatt Hawkes (evatt.hawkes@unsw.edu.au)
- All demonstrators and course staff (contact through moodle):
    - Tracey Yeung
    - Yajie Jiang
    - Alex Wotton
    - Arman Mahboubi-Soufiani
    - Philippe Gentillon-Molina

Where/When:

- Students should attend the two-hour lecture each week, and one two-hour tutorial. There are three laboratory activities requiring approx. 6 hours total are also offered.
- Handbook details: http://www.timetable.unsw.edu.au/2019/SOLA5052.html

Assessment:

- Quizzes, online on Moodle, worth 20% of total mark
    - Weekly (X10)
    - Primer Quiz (week 1)
- One (1) major assignment/quantitative computer-based project on Thermochemical Gasification worth 30% *without labs*, 20% *with labs*:
    - First Assessment: due end of week 6, Sunday @ 12am
    - Final Assessment: due end of week 9, Sunday @ 12pm
- Three (3) laboratory exercises (optional, opt-out on Moodle), run in Chemical Sciences (F10) Rm 165, worth 10% of the total
    - Biochemical gasification of methanol and marine biomass
    - Conversion of waste vegetable oils to clean biodiesel
    - Direct carbohydrate (sugar) batteries/fuel cells for long range electric vehicles
- Final exam worth 50%
- Attendance not directly assessed.
- No mid-term.

And now, the LONG version....

2. Staff Contact Details and Methods of Communication

Contact details:

For most inquiries, please use the course Moodle page to allow all staff to see your message.

Course Coordinator:
Dr. Rob Patterson
TETB (H6), Rm 246
Phone: 9385 0392
robert.j.patterson@unsw.edu.au

Lecturer:
Prof. Evatt Hawkes
Room: TETB (H6), Rm 129
Phone: 9385 4602
evatt.hawkes@unsw.edu.au

Methods of Communication:

We strongly encourage you to ask any questions you might have about the course ***at the tutorials or lectures***. There is ample time to answer all these questions and more within our allotted 2 hrs per week.

Announcements may be made at lectures or tutorials. If for some reason you do not attend, check with classmates whether any important announcements were made. Otherwise, UNSW Unimail and the Moodle site are the primary methods by which course staff will contact you. ***Be sure to check them daily.***

Email is the preferred method by which you may contact course staff outside of the scheduled teaching times. If you have a question which is not appropriate for a demonstrator – e.g. special consideration – please email the Course Manager or Lecturer directly.

Please always include a subject line that is closely related to the content of your email and ***includes the course-code 5052 or 9011 and the word biomass, and sign with your full name and student number.*** Other consultations are by appointment (made by email).

Moodle will be used to disseminate lecture notes and other reference material. Please check Moodle regularly for course information, though important announcements and reminders will also be disseminated in lectures and (if necessary) tutorials.

3. Course Details

Moodle Website: https://moodle.telt.unsw.edu.au/

Credit Points: 6 units

Summary and Aims of the Course

The course aims to introduce biomass (i.e. material of recent biological origin) as an energy carrier and the technologies associated with its exploitation.

Several sources of raw biomass will be considered including forestry, wastes, energy crops, crop residues, and algae. Methods of production, collection, processing these different sources will be covered. Agriculture and silviculture are largely outside of the scope of the course and are only discussed as a means to estimate biomass production.

Several technologies for the conversion of raw biomass into heat, electricity and fuels will be considered. Specifically the following will be introduced:

• Combustion of raw biomass and biomass-derived liquid and gaseous fuels to produce heat and electricity.

• Thermochemical conversion technologies to produce gas fuels, including pyrolysis and gasification, and to produce liquid fuels such as methanol, biodiesel, or hydrocarbons similar to gasoline (petrol) or Diesel fuels.

• Biochemical conversion options to produce gaseous fuels including anaerobic digestion and to produce liquid fuels including via fermentation.

Student Learning Outcomes

As can be seen in the previous section, a large breadth of topics will be considered. The aim is not to become an expert on all of these topics. Rather, the goal is to obtain a broad understanding of various types of biomass resource and various conversion technologies.

At the same time, in key areas, a basic level of understanding of underlying physical, chemical, and biological processes involved will be taught. This approach will enable both interactions with experts in the area and further learning at greater depth.

At the end of the course, students should:

- Explain how the characteristics of biomass resources determine the methods of production, collection, processing and potential conversion to energy or higher grade energy products (syn-gas, biogas).
- Compare and contrast the possible pathways for conversion of different biomass resources into heat, electricity and fuels.
- Solve quantitative engineering problems and perform algebraic derivations relevant to biomass conversion utilizing the governing and operating principles of biomass conversion.
- Evaluate business opportunities for biomass energy conversion using simple biomass resource assessments and fundamental engineering design and problem solving.

Assumed Knowledge

Students should have a good working knowledge of university level physics, mathematics, chemistry, and thermodynamics. There is a strong component of ***engineering calculations*** involving dimensional reasoning and balances of mass and energy.

Graduate Attributes

This course will assist students in their development of the following UNSW graduate attributes (as listed at https://my.unsw.edu.au/student/atoz/GraduateAttributes.html):

1. Understanding their discipline in its interdisciplinary context;
2. Rigorous in their analysis, critique, and reflection;
3. Able to apply their knowledge and skills to solving problems;
4. Capable of effective communication;
5. Information literate;
6. Environmentally responsible.

Developed Competencies

The Engineers Australia policy on Accreditation of Professional Engineering programs requires that all programs ensure that their engineering graduates develop Stage 1 elements of competency (see: http://www.engineersaustralia.org.au/membership/assessment). Listed below are the activities in this course that will help students to achieve at least some of these elements of competency. Note: that not all elements of competency are relevant to each course.

Professional Engineering Stage 1 Elements of Competencies	Activities used to Develop Competency
Knowledge Base	
PE1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline.	Lectures, tutorials, and assignments incorporating fundamental knowledge of mass and energy balances, and the second-law of thermodynamics. Lectures giving fundamental description of processes involved in biomass conversion (eg combustion, gasification, anaerobic digestion).
PE1.2 Conceptual understanding of the mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline.	Lectures, tutorials and assignments developing competence in assessments of biomass resources, conversion technologies, and economics.
PE1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline	Via twelve weeks of two-hour tutorials, and three comprehensive assignments, extensive development of students ability to perform relevant calculations involving biomass energy systems – principally involving detailed mass and energy balances, and basic-level economics.
Engineering Ability	
PE2.1 Application of established engineering methods to complex engineering problem solving.	Tutorials and assignments are designed to promote ability to *independently* solve problems. Problem identification is not strongly emphasized in the course; the focus is mainly on formulation and solution. First-principles based reasoning is developed to solve problems as opposed to a traditional formulaic approach in which students recognize "this is problem type X, therefore I know to apply formula Y".
PE2.2 Fluent application of engineering techniques, tools and resources.	Lectures/ tutorial discussions, and discussion questions in assignments develop the students appreciation of the complexity of the environmental issues associated with bioenergy – namely the positive aspects such as reduced

	carbon emissions versus negatives associated with additional large-scale agricultural production of biofuels.
PE2.3 Application of systematic engineering synthesis and design processes.	Assignment 1 develops systems-based thinking by considering a detailed economic assessment of a short-rotation forestry operation. Assignment 3 is based on a site-visit to an anaerobic digestion facility and several questions focus on appreciation of the systems aspects of the facility.
PE2.4 Application of systematic approaches to the conduct and management of engineering projects.	Not directly developed.
Professional Attributes	
PE3.2 Effective oral and written communication in professional and lay domains.	Preparing written assignments, interacting with demonstrators in tutorials.
PE3.4 Professional use and management of information.	Tutorial and assignment tasks requiring effective representation of data.
PE3.5 Orderly management of self, and professional conduct	Not directly developed.

4. Rationale for the Inclusion of Content and Teaching Approach

The content has been selected to provide a broad coverage of the status and prospects for bioenergy. This will enable effective interactions with experts in the various sub-disciplines involved and will assist high level decision making in the renewable energy area. The teaching approach as outlined below is designed to give both breadth of knowledge through lectures and depth of knowledge in some key topics through tutorials, which also develop crucial skills in problem solving generally. The theoretical material is complemented by invited lectures from industry who describe the business realities of bioenergy projects, with reference to real case studies in their organizations.

5. Teaching Strategies

Lectures will be used to introduce the factual information, theory, and methods of the course. Learning during lectures should be later reinforced by reading reference materials and working through the assignments.

Tutorials will be used to demonstrate how to apply the facts, theory and methods delivered in lectures to idealised problems, to work on assignments and exam practice questions, and for discussion of key points with demonstrators and/or lecturer.

Assignments then further develop (by calculation, critical analysis and discussion) and assess student learning by application to more complex and involved problems.

Laboratory activities will give “hands-on” experience making real biofuels and extracting energy from inexpensive, abundant and non-toxic bio-derived chemicals.

The final exam assesses student learning as a result of the course.

6. Assessment

The overall course mark is comprised of 20% for quizzes, (30% or 20%) for the major assignment, (0% or 10%) for laboratory activities and 50% for the final exam.

Attendance

I do not mark attendance at tutorials or the lectures. However I strongly advise it in order to pass the course. I do give additional information in the lectures and tutorials that is not posted online. Tutorials will be particularly useful because the demonstrators will guide you through a process of problem solving, which will be very helpful in the final exam.

Major assignment (worth 30% without labs/20% with labs)

Assignment 1 – First Assessment due @ 12am Sunday, end of week 6

Final Assessment due @ 12am Sunday, end of week 9

On equilibrium products of biomass gasification (chemical thermodynamics)

Submission of assignments: can be done electronically/online through the Moodle page.

Late assignments will be penalized 30% plus 10% per day that the work is late (i.e. 40% if one day late), to a maximum penalty of 100%, except in highly exceptional and verifiable cases.

Quizzes

1) A 'Primer Quiz', will be given online in week 1. This quiz will provide a re-introduction to concepts necessary for the biomass course that should have been taught previously including dimensional reasoning, thermodynamics, fundamental chemistry and the basics of solving biomass questions.
2) Weekly quizzes (10 total) will be posted on Moodle just after the weekly lecture and will be due (e.g. set to close) just before the start of the next lecture.

Important: No late quizzes will be accepted!

Laboratory Activities (worth 10%, offsets major assignment)

The laboratory activities are designed to provide real, hands-on skills making biofuels and extracting energy from biomass. There are three (3) laboratory activities. They are:

1. **Biogas production:** you will make your own miniature marine bio-reactor and biologically gasify methanol, marine cyanobacterial feedstock (optional) as well as any other biomass feedstock of your choosing (optional). Analysis will be performed using gas chromatography (GC) and the final data will be used to determine the total methane yield from your bio-reactor. Biogas from marine digesters similar to these are attractive for massive-scale implementation since they have essentially no freshwater requirements and couple directly to fast growing marine plants that do not require arable land.
2. **Biodiesel production:** you will make your own biodiesel from waste vegetable oils, as well as new oils (optional, student may provide ~50 mL of oil). You will estimate the total energy in your product biodiesel after following an optimized synthesis recipe and so estimate an overall efficiency for the oil-to-biodiesel conversion process. The International Energy Agency (IEA) projects that advanced biodiesel will play a significant role in future sustainable transport fuels.
3. **Direct carbohydrate fuel cells:** Simple carbohydrates, or sugars, can be obtained from cellulose, which is the most abundant polymer on the planet and a major component of wood. In this lab you will obtain electricity directly from sugar in an electrochemical fuel cell. You will measure the characteristic "warm-up" time and the electrical power output. Electricity directly from sugar has significant potential to replace sugar fermentation to bio-ethanol, providing an energy dense fuel for future long-range electric vehicles.

During the course you will attend 3 lab sessions for a total formal time commitment of about 6 hours. Tutors will be present to guide you through the labs.

Lab notebooks will be marked in the lab and marks recorded by tutors. Any analysis done outside of the labs can be submitted through Moodle.

Important: Students will be required to bring their own lab coats and safety goggles to the lab.

Final Exam

The exam will consist of written short answer questions, calculations and derivations. About half of the marks will be available for short answer written questions that mainly assess the breadth of your knowledge, while the other half will include more involved calculations that assess the depth of your ability to solve relevant engineering problems. All material presented in the course (including via Moodle) is examinable unless otherwise explicitly stated.

If you are ill on the day of the final exam, inform course staff immediately and bring a doctor's certificate.

Scaling

If necessary, overall marks or marks from individual assessments may be scaled.

Parallel Teaching

The Undergraduate and Postgraduate versions of this course are identical. Undergraduate and Postgraduate students will attend the same lectures and tutorials.

Course Times and Locations
This course comprises three to four hours of formal contact per week. The timing and rooms are given below, from http://timetable.unsw.edu.au/2019/SOLA5052.html.

Activity	Time	Location
Lecture (all weeks)	9am – 11am, Wednesdays	Red Centre Theatre (K-H13-G001)
Tutorials (start week 2)	Tut.1: 9am – 11am, Thursdays Tut.2: 2pm – 4pm, Thursdays	Tut.1: Civil Engineering G8 (K-H20-G8) Tut.2: Quadrangle G044 (K-E15-G044)
Labs (start week 2)	L.1: 10am – 12:30pm, Mondays L.2: 2pm – 4:30pm, Mondays L.3: 9am – 11am, Tuesdays	L.1: Chemical Sciences 165 (K-F10-165) L.2: Chemical Sciences 165 (K-F10-165) L.3: Chemical Sciences 165 (K-F10-165)

7. *Resources for Students*

- **Moodle Site:** All handout materials, including lecture notes, tutorials and assignments, and additional optional readings, will be distributed via the official site for this course, at **https://moodle.telt.unsw.edu.au/**. Notes for each lecture will be posted prior to the lecture, or shortly afterwards.
- **Optional Textbook:** Ralph Sims, The Brilliance of Bioenergy in Business and in Practice (James & James, London, 2002, 314 pages, ISBN 1 902916 28 X). It is quite expensive and not perfect, and is therefore optional. The UNSW Library has several copies; the book is also available from the UNSW Bookshop, and through online bookstores. It should be possible to pass the course without owning a copy of the textbook, however it is helpful.
- **Library:** students seeking resources can also obtain assistance from the UNSW Library. One starting point for assistance is: http://www.library.unsw.edu.au/servicesfor/students.html.

8. Course Evaluation and Development

This course was redeveloped in 2019 and is still being improved. At the end of the course, you will be asked to complete a MyExperience survey, the information from which will be used to further improve the course in 2020. Your feedback is much appreciated and is taken very seriously. Please do tell us about your experience with the course, what you liked, what you didn't, what you learned the most from, etc, via the MyExperience survey. Time will likely be allocated to doing this in the lecture near the end of the course.

Otherwise please don't hesitate to come and chat at the end of a lecture or with your demonstrators about any (hopefully constructive) suggestions.

9. Student Responsibilities and Class Policies

1. **Late assignments** will be penalized 30% plus 10% per day that the work is late (i.e. 40% if one day late), to a maximum penalty of 100%, except in highly exceptional and verifiable cases. **Important: No late quizzes will be accepted!**

2. **Attendance and Attention**. Responsibility for earning marks rests solely with the student. It is advised to attend lectures, to avail yourself of the subject resources, to complete your assignments and quizzes on time and to the best of your ability, participate in the tutes, and to be fully aware of the course syllabus, including any announcements or changes to that syllabus.

3. **Plagiarism.** All assignments and tutorials are for individual effort and individual assessment only, with a few exceptions that will be clearly noted. You are expected to be aware of, and you will be subject to, the UNSW and School policies that cover plagiarism of written work. Students *will* be penalised for plagiarism in tutorial, assignment and exam work. See below.

10. What is Plagiarism?

Plagiarism is the presentation of the thoughts or work of another as one's own.* Examples include:

direct duplication of the thoughts or work of another, including by copying material, ideas or concepts from a book, article, report or other written document (whether published or unpublished), composition, artwork, design, drawing, circuitry, computer program or software, web site, Internet, other electronic resource, or another person's assignment without appropriate acknowledgement;

- paraphrasing another person's work with very minor changes keeping the meaning, form and/or progression of ideas of the original;

- piecing together sections of the work of others into a new whole;

- presenting an assessment item as independent work when it has been produced in whole or part in collusion with other people, for example, another student or a demonstrator; and

- claiming credit for a proportion a work contributed to a group assessment item that is greater than that actually contributed.†

For the purposes of this policy, submitting an assessment item that has already been submitted for academic credit elsewhere may be considered plagiarism.

Knowingly permitting your work to be copied by another student may also be considered to be plagiarism.

Note that an assessment item produced in oral, not written, form, or involving live presentation, may similarly contain plagiarised material.

The inclusion of the thoughts or work of another with attribution appropriate to the academic discipline does *not* amount to plagiarism.

The Learning Centre website is main repository for resources for staff and students on plagiarism and academic honesty. These resources can be located via:
www.lc.unsw.edu.au/plagiarism

The Learning Centre also provides substantial educational written materials, workshops, and tutorials to aid students, for example, in:

- correct referencing practices;
- paraphrasing, summarising, essay writing, and time management;
- appropriate use of, and attribution for, a range of materials including text, images, formulae and concepts.

Individual assistance is available on request from The Learning Centre.

Students are also reminded that careful time management is an important part of study and one of the identified causes of plagiarism is poor time management. Students should allow sufficient time for research, drafting, and the proper referencing of sources in preparing all assessment items.

* Based on that proposed to the University of Newcastle by the St James Ethics Centre. Used with kind permission from the University of Newcastle

† Adapted with kind permission from the University of Melbourne.

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11. Other Information

Special Consideration for Illness or Misadventure

If you are unable to submit a piece of assessment on time, or to participate fully in laboratory sessions, due to illness or some other event which was beyond your control, you must follow the central UNSW procedures for seeking special consideration. Details of these can be found at https://student.unsw.edu.au/special-consideration.

Please be aware that requests for special consideration need to be submitted to UNSW Student Central as soon as is practicable after the problem occurs and within three working days of the due date of the relevant assessment task.

Disability Support

Those students who have a disability that requires some adjustment in their teaching or learning environment are encouraged to discuss their study needs with the course coordinator prior to, or at the commencement of, their course, with the Equity and Disability Officer in the school office (9385 7993) or with the Equity Officer (Disability) in the Equity and Disability Unit (EADU) 9385 4734. Issues to be discussed may include access to materials, signers or note-takers, the provision of services and additional exam and assessment arrangements. Early notification is essential to enable any necessary adjustments to be made.

Further information for students with disabilities is available at:

http://www.studentequity.unsw.edu.au/

12. Course Schedule.

(No significant modifications are expected as of the beginning of the course.)

Week:	Date week starts:	Topic:	Major Assignment	Labs:	Quiz	Lecture	Tutorial
1	16-Sep-19	Biomass Resources, Supply Chain	**Assignment 1: Thermochemical Gasification**		**1. Primer Quiz**	**As defined by the weekly topic**	**1**
2	23-Sep-19	Chemical Thermodynamics		**Biogas x4 groups/session**	**2**		**2**
3	30-Sep-19	Gas and Steam Turbine, Power Cycles		**Biodiesel x2, Sugar Fuel Cell x2**	**3**		**3**
4	7-Oct-19	Gasification and Pyrolysis		**Biodiesel x2, Sugar Fuel Cell x2**	**4**		**4**
5	14-Oct-19	Combusion of Solid Biomass Fuels		***Biogas Results*, Biodiesel x2, Sugar Fuel Cell x2**	**5**		**5**
6	21-Oct-19	Guest Lecture (Belinda Layson, Tony Esplin)	**1st ASSESSMENT**	***Biogas Results*, Biodiesel x2, Sugar Fuel Cell x2**	**6**		**6**
7	28-Oct-19	Guest Lecture (Earthpower)		**Biodiesel x2, Sugar Fuel Cell x2**	**7**		**7**
8	4-Nov-19	Biochemical Gasification, Anaerobic Digestion		**Biodiesel x2, Sugar Fuel Cell x2**	**8**		**8**
9	11-Nov-19	Liquid Biofuels for Transport	**FINAL ASSESSMENT, SOLVER**	**Catch Up Session**	**9**		**9**
10	18-Nov-19	Exam Preparation {No Lecture}		**Catch Up Session**	**10**		**10**